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Design Technology

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Preface

This resource supplements the text:

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published in print form by IBID Press.

It is not intended to be a stand alone resource for the IB Diploma Course.

We have produced this resource to provide a few of the things that are difficult to include in print media:

- Video material.
- Additional photographs.
- Enlargements of the more detailed diagrams from the text.
- Internet links.

The main intention of this resource is to support the cross-curricular objectives of the IB Diploma courses.

Chapter 1

Human Factors and Ergonomics

CONTENTS

Cover Photo: The Grand Canyon from a helicopter.

The pilot on command of a fixed wing aeroplane sits in the left seat. The pilot in command of a helicopter sits in the right seat.

Gallery 1.1 Some Traditional 'Hand Tools of the Trade'. How is it done now?

A treddle lathe

Gallery 1.2 Built for Discomfort?

The surprisingly sparse interior of the world's first supersonic civil aeroplane, Concord(e).

Chapter 2

Resource Management & Sustainable Production

Section 1

Resource Management & Sustainable Production

CONTENTS

Our cover picture shows a part of the Hellisheiði (pronounced Hedlishethi) geothermal power station in Iceland - one of the largest geothermal power stations in the world.

A gallery of photographs appears on the next page.

http://www.or.is/en/projects/hellisheidi-geothermal-plant

Don’t miss the guided tour: click on the ‘Production cycle’ link.

The plant produces 300 MW of electricity and 400 MW of hot water for heating in the capital, Reykjavik.

The main heat source is 2km underground.

Gallery 2.1 Hellisheiði Geothermal Plant

Entrance Hall

Of course, there are disadvantages to living in an area suitable for geothermal energy - earthquakes and volcanos.

The farm show has its own geothermal electricity generator.

However, it lies at the foot of Eyjafjallajökull (pronounced eya-fetla-jokurt). This volcano erupted in 2010 causing widespread disruption to European Civil Aviation. The heat melted part of the glacier, causing flooding in the area shown. All damage is now repaired.

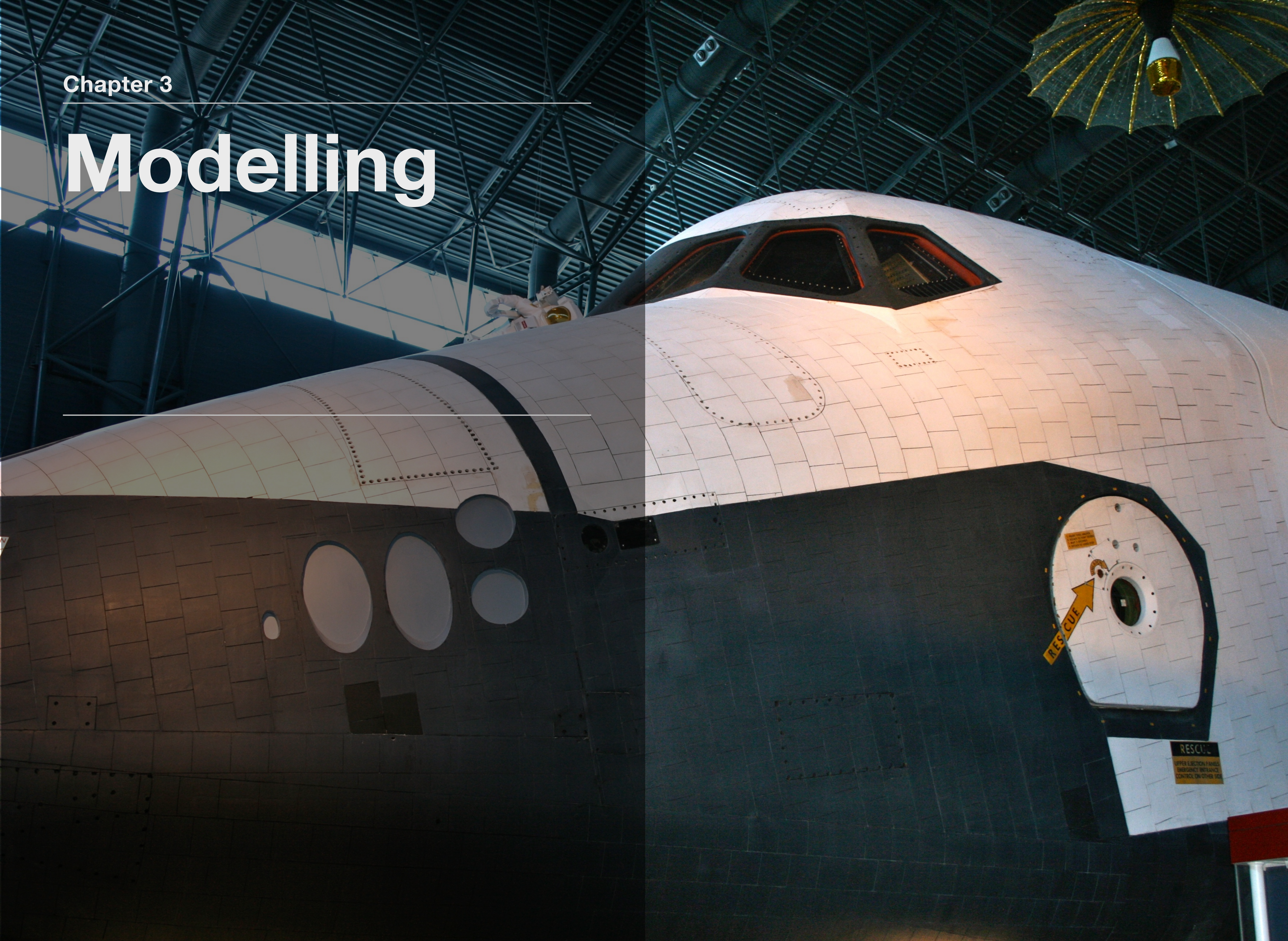
The Hoover Dam in Nevada, USA is one of the largest hydro-electric schemes in the world. Other benefits are water for irrigation and the flooding that was common from the Colorado river.

Not all ‘rubbish’ damages the environment. Wrecks, oilrigs, jetties etc. are often havens for marine life.

Movie 2.1 A WW2 aeroplane and a mini-sub. Papua New Guinea

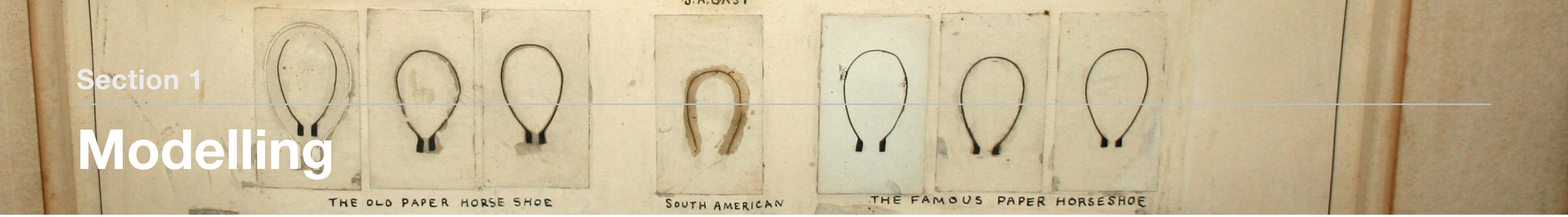
Chapter 3

Modelling



Section 1

Modelling



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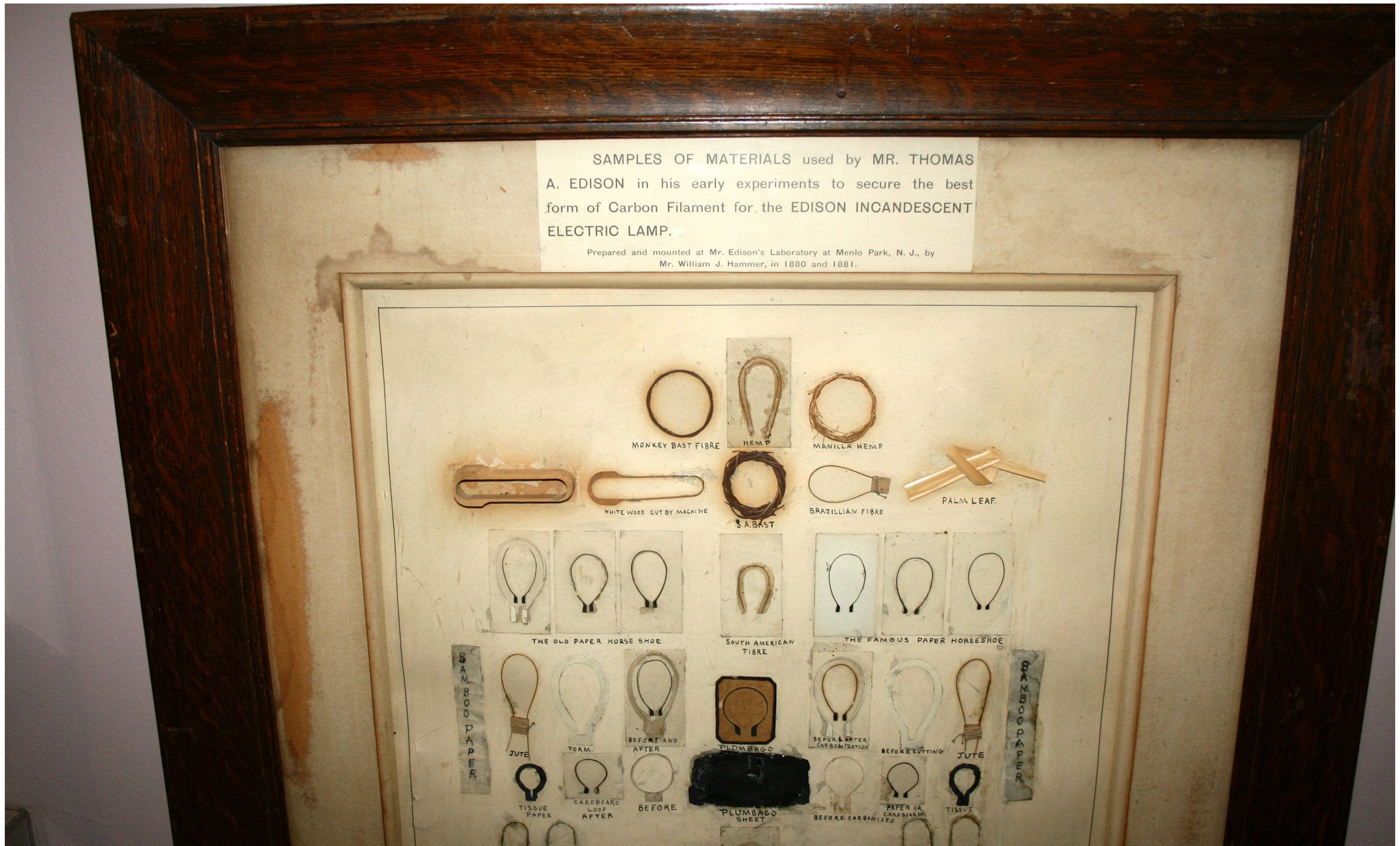
Our cover picture shows the full scale model of the space shuttle.

It never flew in space, but did confirm many vital features such as the fact that it could glide to a safe landing.

The model is preserved in the Udvar-Hazy section of the Smithsonian Institution, just outside Washington, DC.

The banner shows a few of Edison’s attempts at perfecting the filament for the incandescent light globe. (Smithsonian Institution).



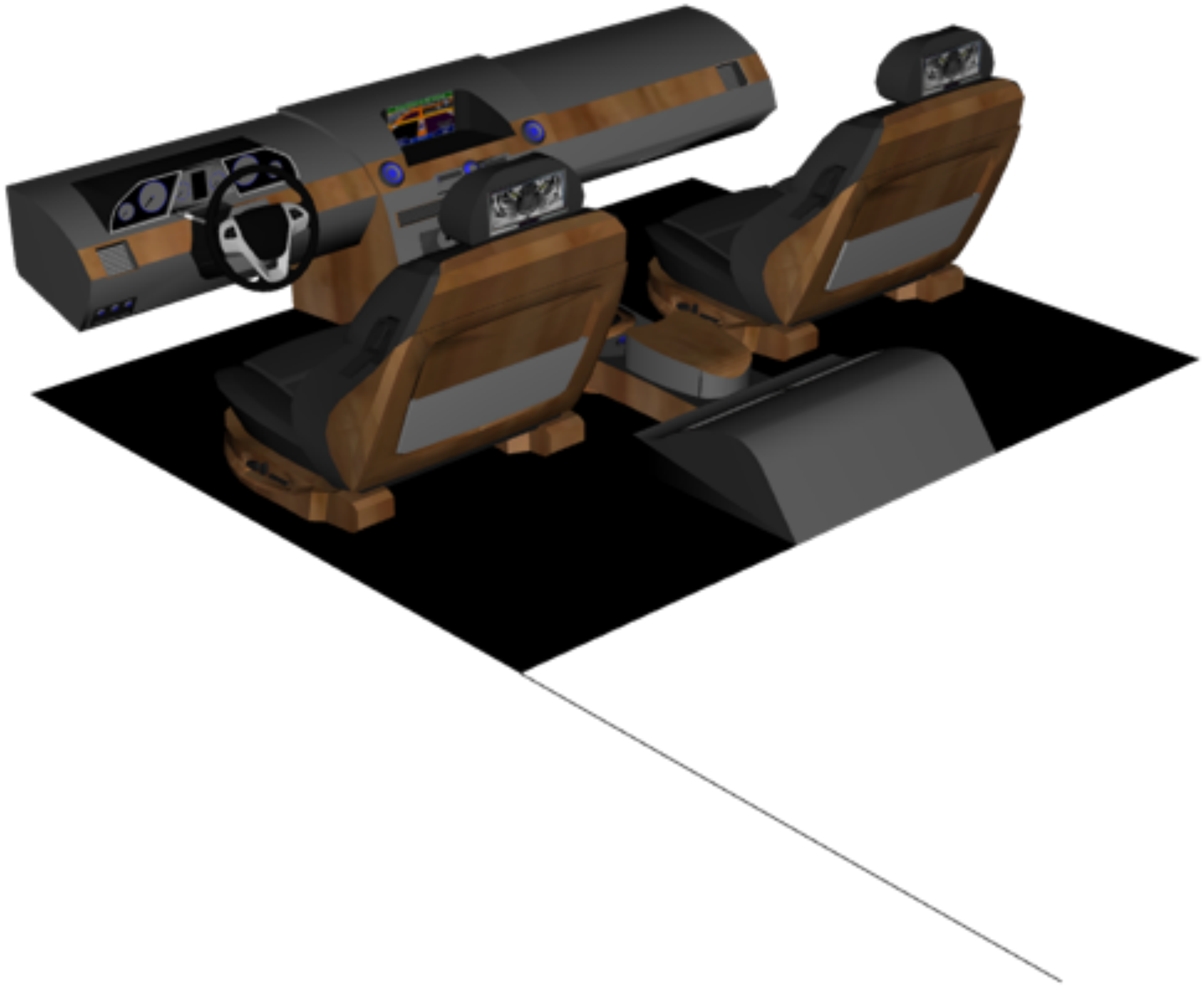
Gallery 3.1 Some models made by the British Aluminium Company in the 1950s to show uses for aluminium.

Cast cigarette box.

Interactive 3.1 3d Virtual Table

Library model

Interactive 3.2 3d model of car interior



Library file.

Theory of Knowledge:

How is new knowledge acquired through the use of digital models?

Through the integration of design, manufacturing, construction and testing into one seamless package Bhavna (2013) believes digital design and digital design models have, “begun to emerge as a significant ideational

resource for design.” These models allow designers to test ’what if’ scenarios without recourse to physical modeling or prototyping. This process speeds up the design cycle and allows for faster cycle times or the testing of a greater range of possibilities. Materials, designs, manufacturing techniques, in-use scenarios, economic and environmental impacts may be examined in virtual environments before moving to prototyping or physical testing of any kind. Solutions may be evaluated in multiple combinations, many of which may be difficult for designers to replicate in real life.

- Does technology allow us to gain knowledge that our human senses are unable to gain?

There are many things technology cannot do that humans are capable of, however, there are also opportunities for technology to exploit its strengths in its ability to gain knowledge. Our human senses may indeed be enhanced through the application of technology to reveal knowledge about the world previously unavailable. This knowledge is not just a matter of degree or quality but in many cases offers insights previously unavailable.

Many of these technologies are old and commonplace while others are new and innovative.

The human eye can view the visible spectrum and distinguish between approximately 10 million colours. Our eyesight may be enhanced through a range of technologies to see things small and large but technology can also reveal much that is hidden. X-rays, MRI, radio telescope, night-vision, infrared, heads-up displays, augmented reality, scanning electron microscope technologies and so on all reveal new information about the visual environment.

Hearing is our recognize sounds through vibrations. Audio technologies such as hearing aids and stethoscopes may improve our perception of the world while others technologies can expose sounds that are not within the range of human hearing such as ultrasonic and infrasonic sounds. These technologies may be used for defect detection in materials (ultrasound), echo location for revealing objects under water (sonar) or noise cancelling technology to declutter environments and isolate critical information.

Through four main types of receptors: mechanoreceptors, thermoreceptors, pain receptors, and proprioceptors, our sense of touch registers texture, pressure, vibrations and other sensations associated with tickle, itch and pain, The BioTac® system is technologies response to touch. Designed to mimic a human fingertip it can detect measure and transmit information relating to pressure, temperature, vibration and texture. Finding use in the fields of prosthetics and remote handling it is in the early stages of development and yet to replicate the full range of capabilities of the human sense of touch.

Olfaction is the sense of smell. Possessing about six million olfactory receptors an individual can identify thousands of different smells and is able to detect odours at the single molecule level. Achim Lilienthal's Mobile Robotics and Olfaction Lab, is developing a mobile robotic sensor designed to detect locate gas leaks and work in hazardous environments such as landfill sites, yet, as Lilienthal states, "one reason digital olfaction is so complex is the number of disciplines that need to work together."

Gas detectors have long been used to detect hazardous environments and from this technology has come the development of a device that can "smell" cancer cells in a patients breath. Currently under going trials this technology may revolutionise cancer detection and treatment.

Taste as a sense is a complex combination of sensations enhanced by smell, texture and temperature. In an effort to replicate or standardise taste Thai scientists have developed an electronic taste test to verify Thai food against a government-developed database of approved standard recipes. This allows very precise control over food production facilities.

3.3 Physical modeling

Physical modeling allows designers to explore and test their ideas. The 5% scale model rocket shown provides NASA design engineers with data in a range of fields including acoustics, noise suppression systems and internal noise comfort levels for astronauts. This ‘green run’ approach ensures all components have been exposed to launch and flight-like conditions prior to commissioning.

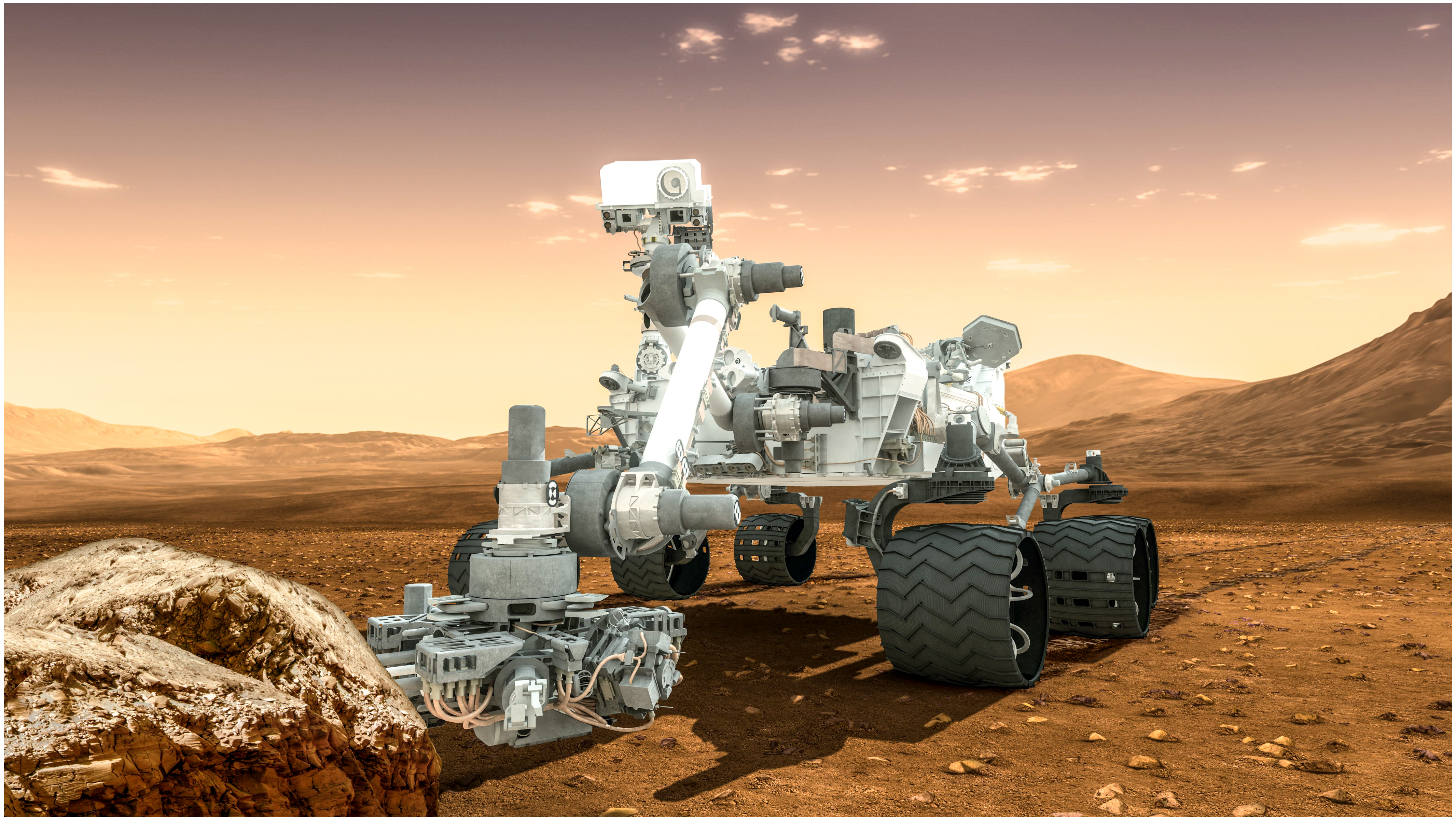
Photo credit: NASA/MSFC/David Olive

3.4 Computer-aided design

The ability to virtually prototype, visualise and share concepts enables designers to analyse products in virtual environments before deploying more expensive field testing. The image shows a design concept for NASA's Mars Science Laboratory Curiosity rover.

This animation (http://www.jpl.nasa.gov/video/details.php?id=1189) simulates the rover drilling a hole to collect a rock-powder sample.

Photo credit: NASA/JPL-Caltech



Chapter 4

Raw Materials to Final Production

Section 1

Raw Materials to Final Production

CONTENTS

Cover photo: The main open cut mine, Kalgoorlie, Western Australia

One of the last of the ‘tea clippers’ - *Cutty Sark*. Not the metal cladding of the wooden hull below the waterline. This is copper sheeting. The copper prevented the growth of barnacles (shell fish) that increased the drag on the hull, slowing the ship. The phrase “copper bottomed” meaning “very good” is derived from this innovation.

The hull of the *SS Great Britain*. One of the first ships to be made of iron and the first to use a propellor (as opposed to sails or paddles).

The Lockheed Blackbird made extensive use of titanium.

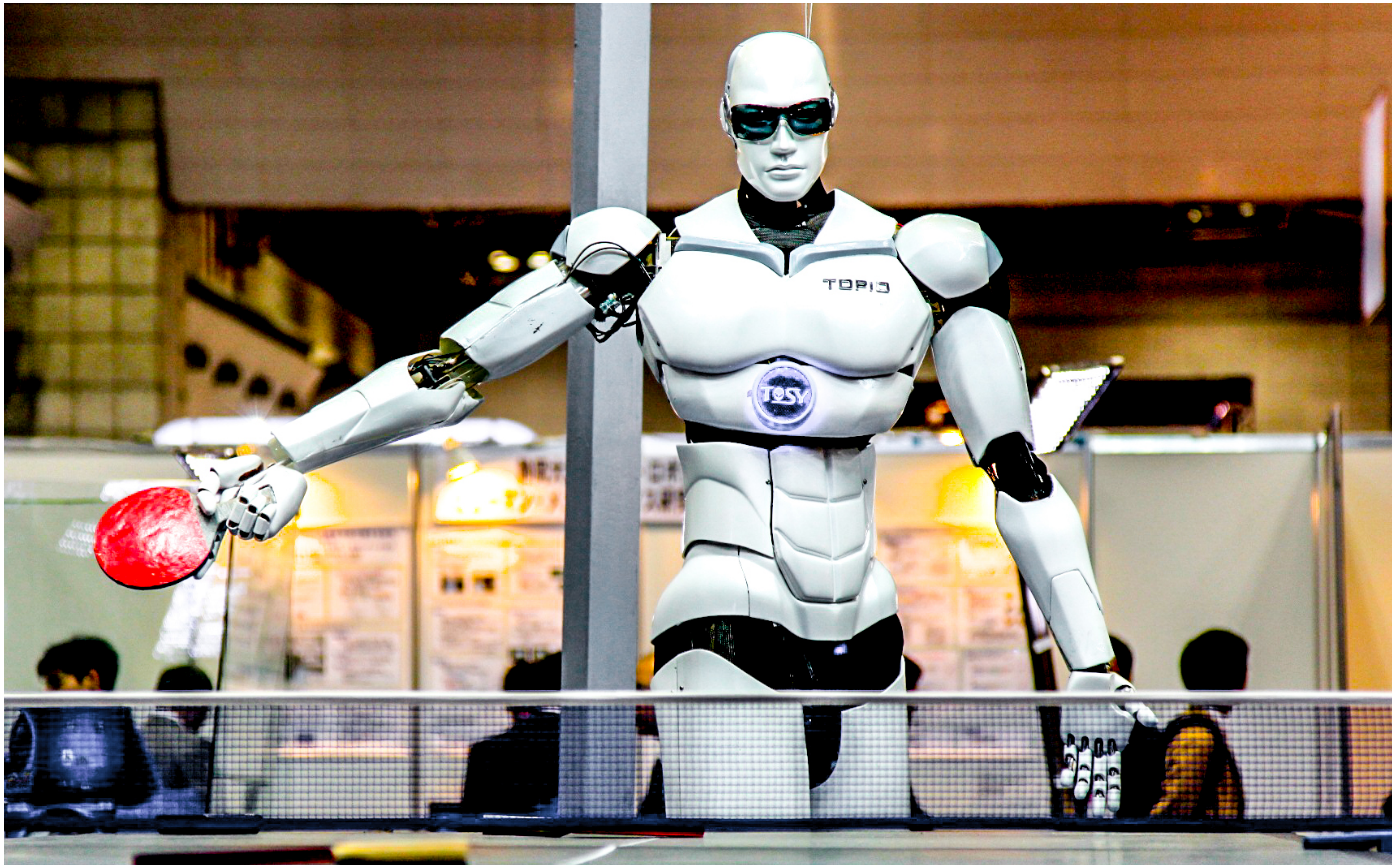
Materials are selected for manufacturing products based primarily on their properties.

Cable stay bridge over the Danube in Bratislava.

4.2j Robots in automated production

Robotics continues to develop in ways that mimic human operations. How may these help manufacturing? TOPIO ("TOSY Ping Pong Playing Robot") is a bipedal humanoid robot designed to play table tennis against a human being.

Photo credit: Humanrobo (Own work) [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons. Video: https://www.youtube.com/watch?v=NZZOgT8oct4



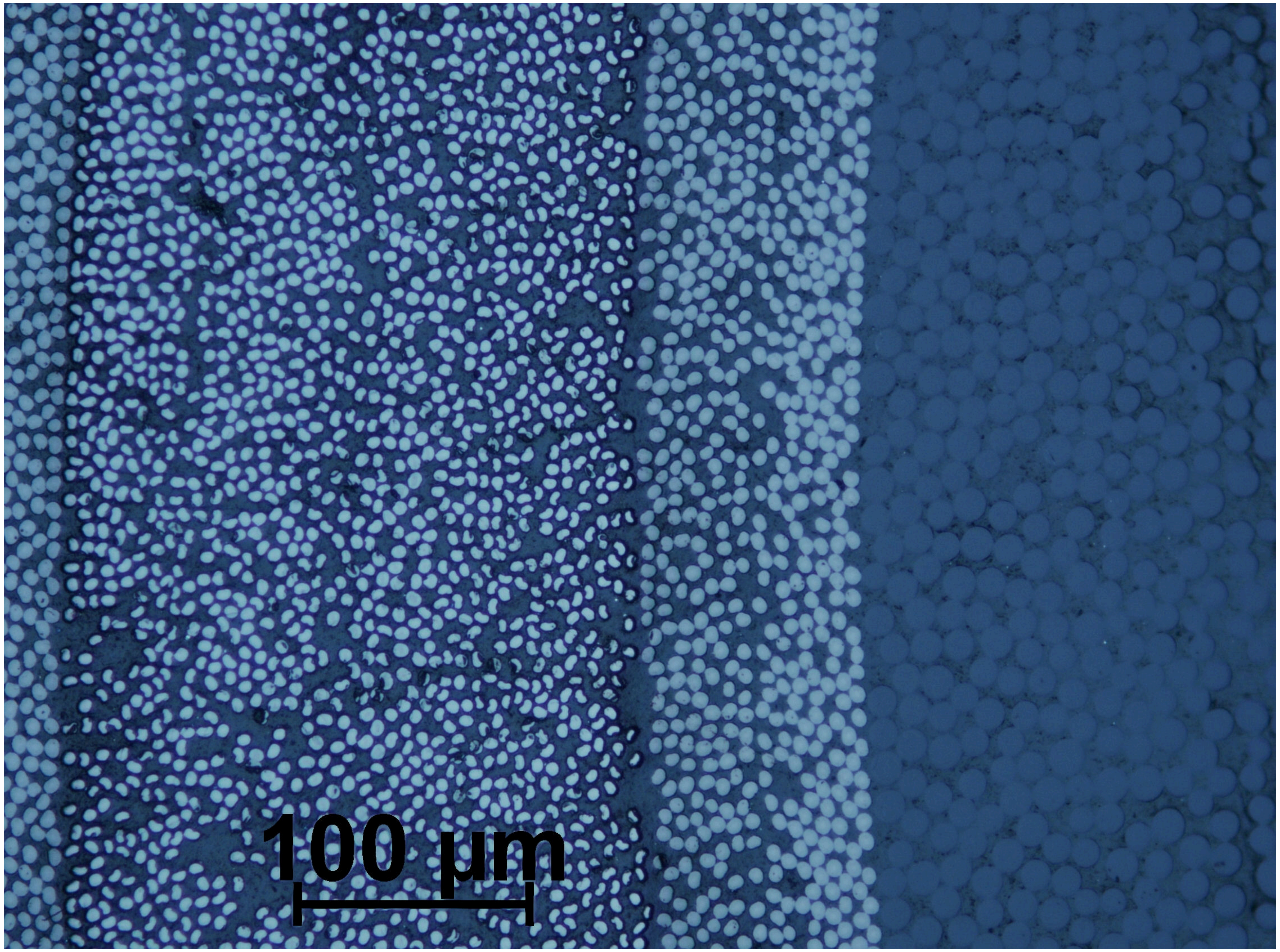
4.2a Metals and metallic alloys

Designers are able to specify metals of a particular composition that may have their mechanical properties modified by alloying, work hardening and tempering. The image shows the varying cross section of a cold rolled bridge plate joined to a wrought iron girder with a forged rivet. All of the materials have varying properties due to composition and manufacturing methods.

4.2f Composites

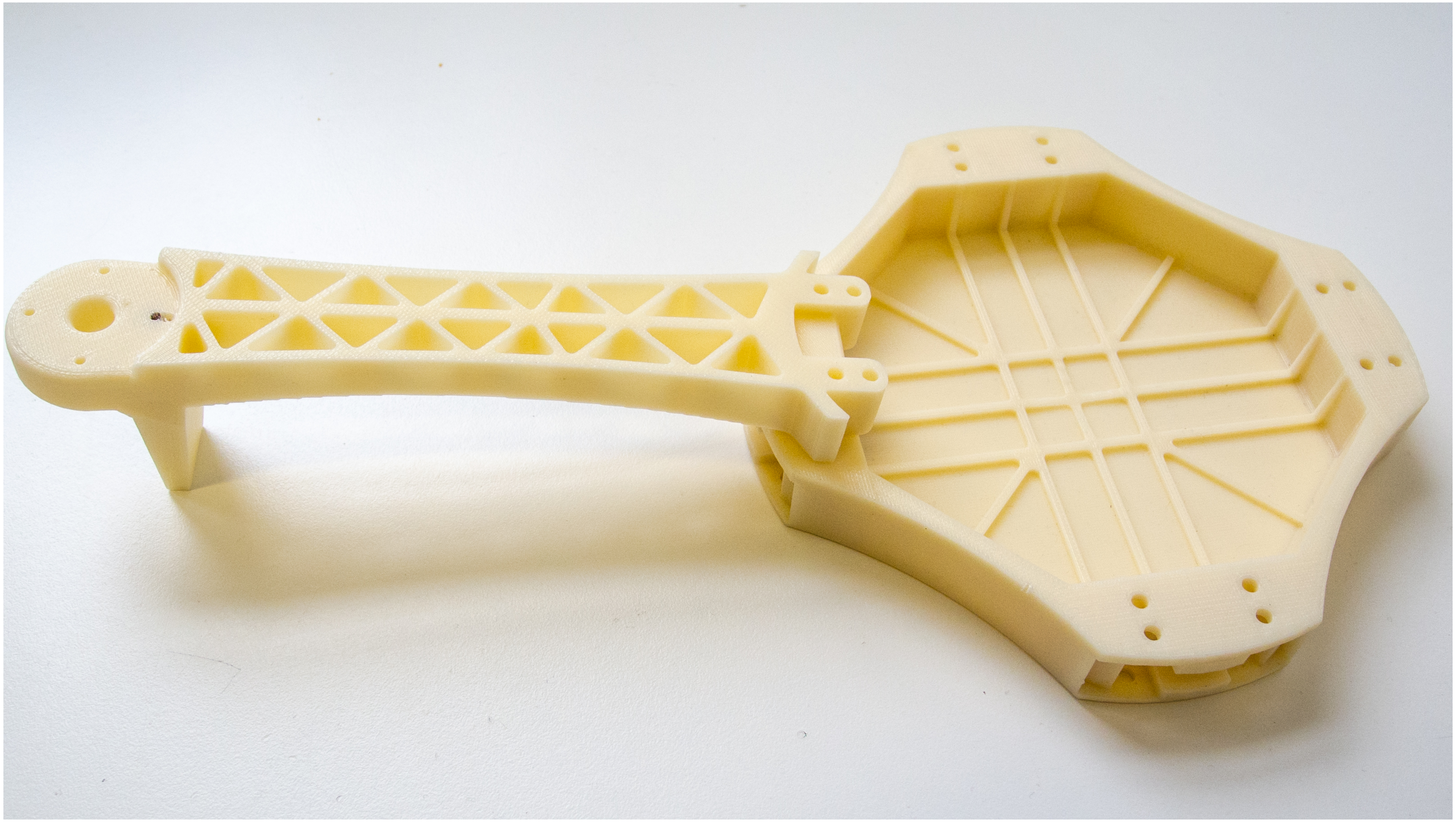
Manufacturers are able to create consumer products in complex shapes quickly and easily using composites to deliver physical and mechanical previously unavailable.

This SEM image of a tennis racquet frame is taken using Back Scattered Electrons (BSE) which shows differences in atomic weight. In the image you can see, end on, the glass and carbon fibres in a polymer matrix (magnification X 200).



4.4 Manufacturing processes

Advancements in technology have resulted in the ability of inexpensive 3D printers at home being able to produce complex shapes.



Chapter 5

Innovation and Design

Section 1

Innovation and Design

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Cover photo: San Francisco Cable-Tram invented by Abner Doubleday who is also credited with the invention of Baseball.

Gallery 5.1 Some aircraft designs that did and did not ‘make it’.

The tilt engine made this a helicopter/fixed wing hybrid.

Gallery 5.2 Motifs from nature frequently copied by designers

Camouflage

5.2 Innovation Biomimicry

The DelFly Explorer is , a 20 gram flapping wing micro air vehicle (MAV) with stereo camera and onboard image processing to achieve autonomous collision free flight.

Video: https://www.youtube.com/watch?v=tNPfD9l14Js

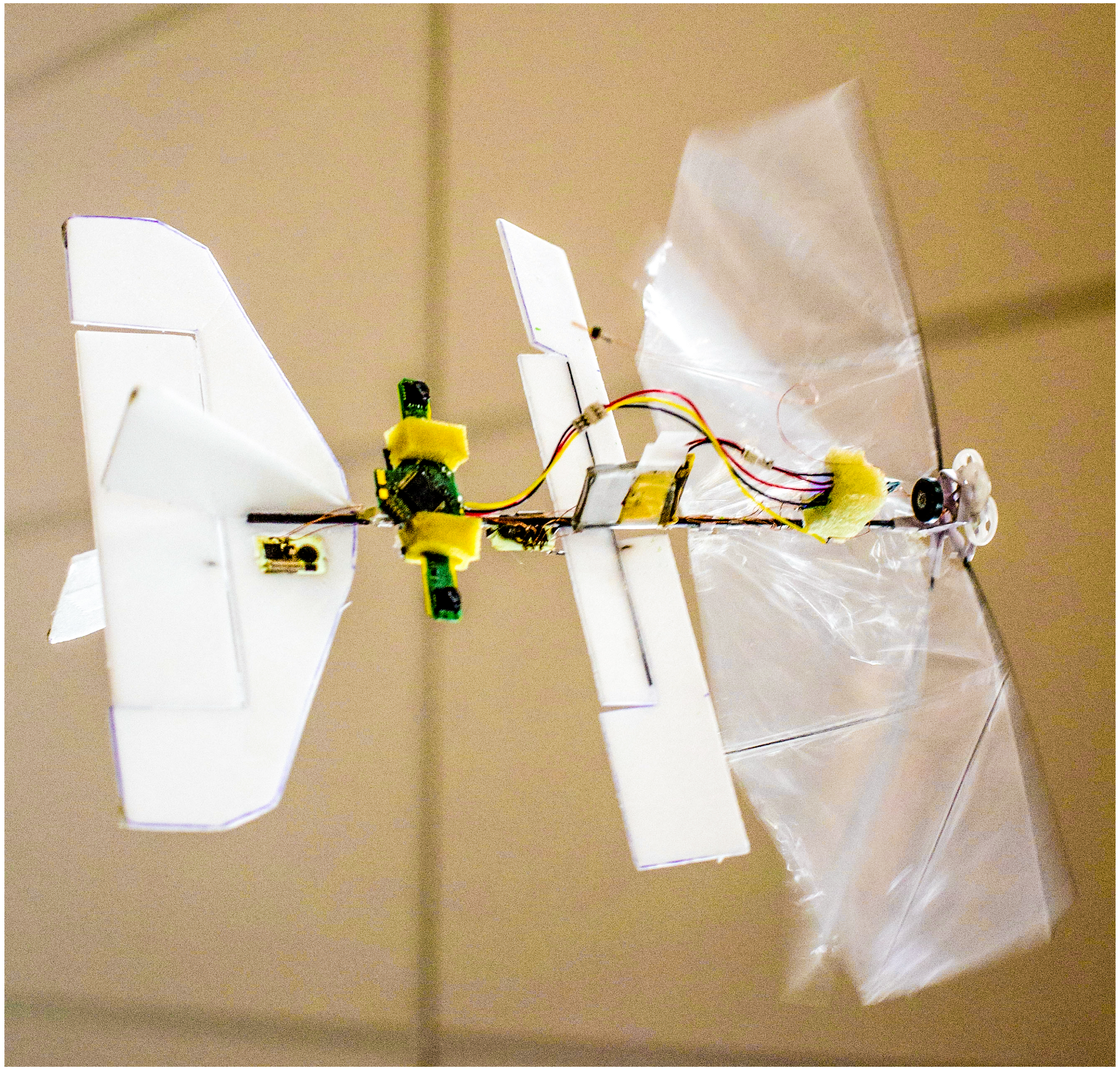
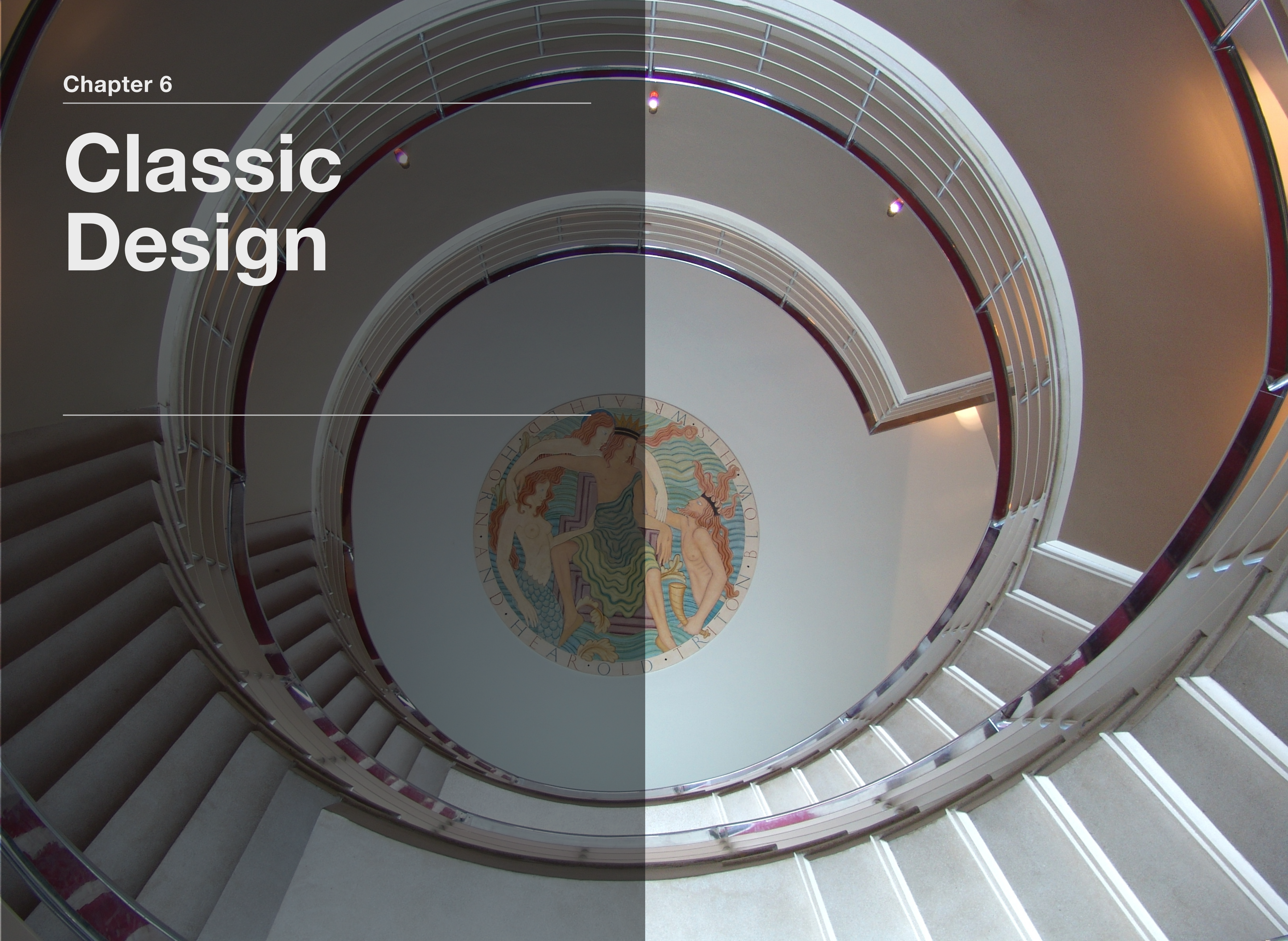


Photo credit: "DelFly Explorer 2013 V1" by Cdewagter - TUDelft, the Netherlands, Micro Air Vehicle Lab. CC BY-SA 3.0 via Wikimedia Commons

Chapter 6

Classic Design



Section 1

Classic Design

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Cover Photo and below: The De La Warre Pavilion, Bexhill, Sussex, UK.

Gallery 6.1 Classic Designs?

Can you identify these?

There are designs that deserve the classic label, but don’t quite make it!. Seen in Fiji.

And the ultimate classic - the Supermarine Spitfire.

International-mindedness:

Classic designs are often recognized across culture and hold iconic status.

Classic designs exhibit features that have caused them to valued over extended periods of time. Highly desirable qualities such quality of construction, timeless form that defies obsolescence and dominance in their field makes these items highly recognisable. Seemingly omnipresent, these designs infiltrate themselves into many cultures and are often pursued because of the perceived social status that accompanies their ownership.

Figure 6.1.4 Design classic - Barcelona chair

The Barcelona chair featured in Figure 6.1.4 embodies all of the features of classic design that have made it recognisable as a global, cross-cultural classic for almost 80 years. A feature of design icons the fact that they are often copied by others

attempting to cash in on the popularity of the product. In many cases this makes the original even more desirable.

Theory of Knowledge

Classic design often appeals to our emotions. Are emotions universal?

Students should consider the nature of emotions [1]. What are emotions? What is their purpose? How do individuals respond to emotional cues? Why do individuals respond differently to the same stimuli, and lastly how does this relate to design, in particular, classic design

Students may choose to investigate the universality of emotions and the range of responses from both individuals and groups. They may also examine the role culture plays in shaping emotional responses. [2]

Don Norman, in his book Emotional Design: Why We Love (or Hate) Everyday Things [3], examines emotional responses to design and postulates “the emotional side of design may be more critical to a product’s success than its practical elements.”

[1] Ortony A., The Cognitive Structure of Emotions, Cambridge University Press, 1990.

[2] Tsai, J.L. The cultural shaping of emotion (and other feelings). In R. Biswas-Diener and E. Diener (Eds.). Noba textbook series: Psychology. Champaign, IL: DEF Publishers, 2013.

[3] Norman D., Emotional Design: Why We Love (or Hate) Everyday Things, Basic Books, 2007.

Exercise

Gather a range of products from children’s toys to domestic appliances. Unveil each of the products to a series of test subjects and ask them to record one word that may express an emotional response if any to the product. Examine the responses at the end and determine if any patterns or trends occur considering such categories as age and gender. Where the responses uniform or were there significant variations?

Movie 6.1 Classic streamlining in action!

6.2 Classic design, function and form

How many different variations of a simple teapot design exist? Do they all exhibit the classic design principle “form follows function”.

Teapot (photo)

Chapter 7

Innovation and Design

Section 1

Innovation and Design

CONTENTS

Cover Photo: ‘Supertrees’ at Gardens by the Bay, Singapore.

See: http://www.gardensbythebay.com.sg/en/home.html

to discover the many innovative features of these structures.

Gallery 7.1 Further Innovation

A Sri Lankan 'tuk-tuk'. Has there ever been a machine better fitted to its purpose?

Gallery 7.2 The Evolution of the Lifeboat. What innovations are evident?

The MV Explorer *in Antarctica, 2001. The vessel sank in 2007 (under new ownership). The lifeboats saved everyone on board.*

Gallery 7.3 Steps in the development of railways.

Locomotion (replica) - 1825

7.2 Usability

The folding chopping board shown leverages multiple properties of polypropylene to bring a new functionality to a product traditionally made from timber. Cutting board (photo)

7.4 Strategies for user-centred design (UCD)

What are the arguments surrounding testing houses versus usability laboratories?

Testing (photo credit U S Food and Drug Administration)

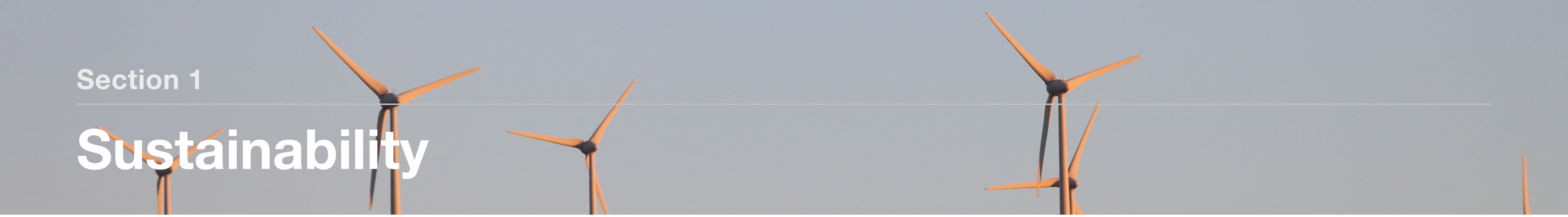
7.5 Beyond usability—designing for pleasure and emotion

Why have designers throughout history embellished even the most utilitarian of objects.

Box iron manufactured in brass (photo)

Chapter 8

Sustainability



Section 1

Sustainability

CONTENTS

Cover Photo: Hydro Power in New Zealand.

Gallery 8.1 How ‘Sustainable’ are these examples?

Alumina.

Chapter 9

Innovation and Markets

Section 1

Innovation and Markets

CONTENTS

Cover Photo: A Director of IBID Press is shown the latest thing in railway engines by his mother - Festival of Britain, 1951. Everything was young once!

Theory of Knowledge

Is strategic planning more influenced by reason, intuition or imagination? Or by a combination of all of the ways of knowing?

Strategic planning appeared in the mid-1960s and was touted as a scientific approach to improving business effectiveness, efficiency and competitiveness. The system is based on gathering data for analysis and synthesis before formulating a plan.

In contrast David et al1, (2009) claim, “Mintzberg’s notion of ‘crafting’ strategies embodies the artistic model, which suggests that strategic decision making be based primarily on holistic thinking, intuition, creativity, and imagination.”

Patterson et al2, (2012) decry the sole use of research data-derived decision making. Interestingly, they use data to propose an argument that “respects and legitimises the power of intuitive insight.”

Students investigate a number of sources that promote one, the other, or a combination of strategic planning approaches.

Some examples of famous entrepreneurs and their thoughts are recorded below

Steve Jobs of Apple Inc. is famously quoted as saying, “It's really hard to design products by focus groups. A lot of times, people don't know what they want until you show it to them.” In this situation the underlying argument is that to be innovative you have to ‘push the boundaries’ and basing future innovative directions on past customer experience may be flawed. Jobs leveraged the skills of extremely innovative product design and marketing teams but did not necessarily plan in the traditional ways based on consumer data.

Henry Ford is another innovator from a different time and context who claimed customer feedback would have hindered strategic planning for his industry changing development plans when he said, “If I had asked people what they wanted, they would have said faster horses.”

1 David et al, The Quantitative Strategic Planning Matrix, The Coastal Business Journal, Vol 8, No1, Spring 2009, 42-52

2 Anthony Patterson, Lee Quinn & Steve BaronThe power of intuitive thinking: a devalued heuristic of strategic marketing, Journal of Strategic Marketing, Vol 20, Issue 1, 2012, 35-44

9.5 Branding

Mercedes SLS (photo)

Branding creates an identity for a product or company. How do marketers use branding to create need, perceived social status and add value to a product?

Chapter 10

Commercial Production

Section 1

Commercial Production

CONTENTS

Our cover photo shows part of a heavy chemical engineering plant.

Theory of knowledge

Manufacturers decide whether to pursue JIT or JIC as a production strategy depending on their perception of where the market is going. To what extent do different areas of knowledge incorporate doubt as a part of their methods?

Over time a series of socio-political events have eroded manufacturer's confidence in their ability to predict the range of variables required to maintain the efficiencies offered by JIT systems. How can manufacturers plan when seemingly unpredictable, random events may affect supply chains, distribution networks and the cost of commodities? In a global market, businesses require modelling to predict currency exchange futures, oil and energy supply, disruptive weather events, etc. Unpredictable events such as government changes, random acts of terror and natural disasters can all have an effect on local and global supply and/or manufacturing.

Alternative supply sources, transportation contingencies and even modified marketing plans all form part of a modern response to the unpredictable. In some industries, fickle and constantly changing fashion trends impact markets and consumer behaviour. Fashion trends may extend to include design features such as: shape, form, colour, style, materials, finish etc. Fashion trends appear in a diverse range of fields including, but not limited to: vehicles, architecture, food, clothing, jewellery, footwear, etc. These trends may be influenced by popular culture, celebrity endorsements, etc. This level of uncertainty must also be taken into account when formulating long-term business plans.

This question is largely about how can we make predictions about the future with any certainty. How do different areas of knowledge make such decisions, what method do they use, and how do they deal with doubt?

Students could consider how religious systems comfort the believer and how the faithful deal with doubt? [1].

How does science deal with doubt? The Nobel Prize winning physicist Robert Feynman suggested that 'Scientific knowledge is a body of statements of varying degrees of certainty -- some most unsure, some nearly sure, none absolutely certain.' [2]. Indeed, the scientific method is based around questioning of received knowledge for conformance with observation and quantification, where possible, of uncertainty and doubt.

Many areas of human activity must incorporate doubt into the decision making process. Examples can be found in foreign affairs, diplomacy, policing, peacekeeping, foreign aid, agriculture and economics [3]

Students could usefully explore any of these areas of human knowledge for examples of the incorporation of doubt.

[1] Jordan, J. (2008). Theistic belief and religious uncertainty. [Available Online].

[2] Feynman, R. (1988). “What Do You Care What Other People Think?” Further adventures of a curious character. W.W.Nornton & Co.

[3] de Graaf, F.J. (2010). Economics, Scientific Doubt and History. European Foundation for Management Development Global Focus, Vol. 4(1), pp. 48-51. [Available Online]